Real-Time Speckle Imaging for Video Surveillance

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Atmospheric blurring, sensor platform motion, and optical aberrations reduce the resolution and contrast in surveillance images recorded over long (>0.5 km) atmospheric paths. The resolution loss can be an order of magnitude or more. In previous work we have demonstrated that we can overcome this loss and restore the resolution to near the diffraction limit, making it possible to identify people from several kilometers and vehicles from multiple tens of kilometers. The original prototype system acquired and processed data far too slowly for most real-world applications, requiring the target to remain still for 2 to 3 min during data acquisition, and then wait 10 to 30 min or more for a processed image.

The objective of this new project is to test a real-time implementation strategy for high-resolution speckle-imaging systems.

Project Goals

The goals of the project for FY2004 were to continue to work on the user interface and speed up work on the speckle-processing capabilities we focused on in the first year of the project. Specifically, we planned to 1) parallelize the speckle-processing software over the four processors of our Quad Xeon server, with expected processing times under 20 s for many cases; and 2) perform field testing of the system with static and slowly moving targets.

Relevance to LLNL Mission

This high-resolution imaging capability is potentially very important for the intelligence and DoD communities as well as for law enforcement and security agencies. LLNL is continuing to play a key role in the development of this capability.

FY2004 Accomplishments and Results

Over the course of this project, we have accomplished our stated goals and more. We have achieved successful video-rate image data acquisition and display using a 2-mega-pixel CCD camera (1600-x-1200 10-bit pixels) and a camera-link frame-grabber with a 512-MB buffer; converted all speckle software to C; and performed parallelization using threads. For image sizes of 1024 × 1024 pixels or greater, we observed a three-times speedup in the total processing time using all four processors of the Quad Xeon server. We achieved processing times of 20 s for 30 frames of 1024-x-1024-pixel-sized images, and 5 s for 30 frames of 512-x-512-pixel-sized images, out to the highest resolution and using image quality parameters that resulted in minimal artifacts.

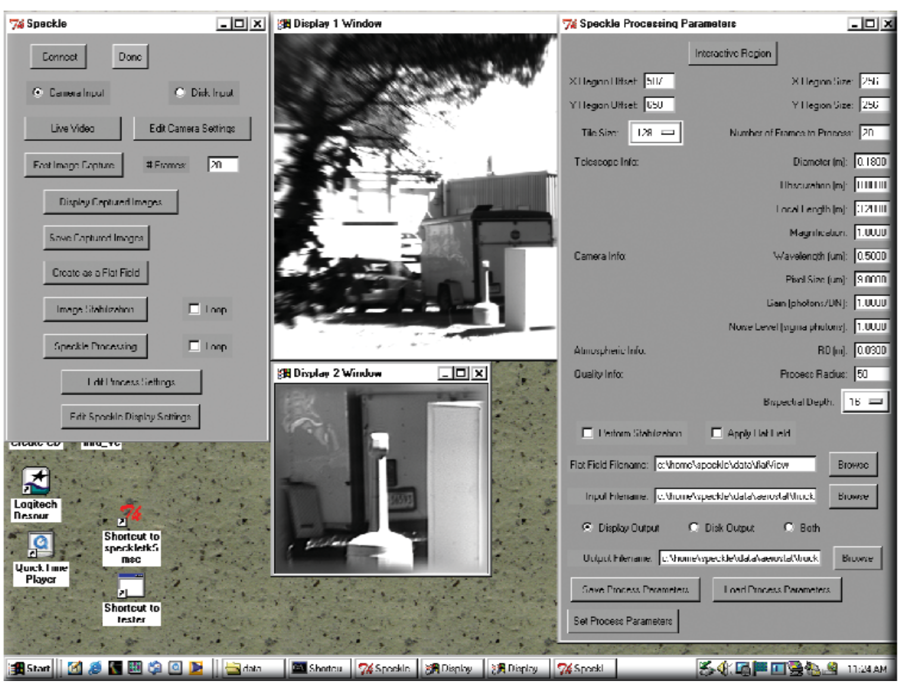

Figure 1. Screenshot of user interface showing main control window (left) and speckle-processing parameters window (right). A sample interactive region of interest selected from the upper center image is shown in the lower center image loaded.

This year we implemented a functional user interface (Fig. 1), including cross platform compatibility with Linux and Windows operating systems, and the ability to perform interactive region-of-interest selection for the speckle processing. We have also produced a battery operable laptop version for remote experiments.

We have conducted successful experimental field-testing of the Linux server system at Site 300 and of the laptop system on Mt. Diablo. Figure 2 shows a sample result. Figure 3 is a photograph of the real-time video-surveillance system being tested outdoors.

Partnering with DOE, we enhanced our imaging project to achieve its science goals of imaging moving targets.

Finally, in FY2004, we defined two potential paths to video-rate processing, one using a DSP board architecture and the other using a compute cluster with high-speed interconnects.

Related References

1. Carrano, C. J., "Speckle Imaging Over Horizontal Paths," *Proceedings of the SPIE-High Resolution Wavefront Control: Methods, Devices, and Applications IV,* **4825,** pp. 109-120, 2002.
2. Carrano, C. J., and J. M. Brase, "Horizontal and Slant Path Surveillance with Speckle Imaging," *AMOS Technical Conference Proceedings,* 2002.
3. Carrano, C. J., "Progress In Horizontal and Slant-Path Imaging Using Speckle Imaging," *Proceedings of the SPIE-LASE2003 Optical Engineering,* **5001,** pp. 56-64, 2003.
4. Carrano, C. J., and J. M. Brase, "Adapting High-Resolution Speckle Imaging to Moving Targets and Platforms," *SPIE Defense and Security Symposium,* **5409,** 2004.

FY2005 Proposed Work

We plan to modify the high-resolution speckle-imaging algorithm flow to allow for continuous updating of the high-resolution output image with each new input image. The current version takes a block of N input images and creates a single output image. We will then implement the continuous-update speckle software on our new nine-node Opteron computing cluster with Infiniband interconnects for the purpose of running at video rates.

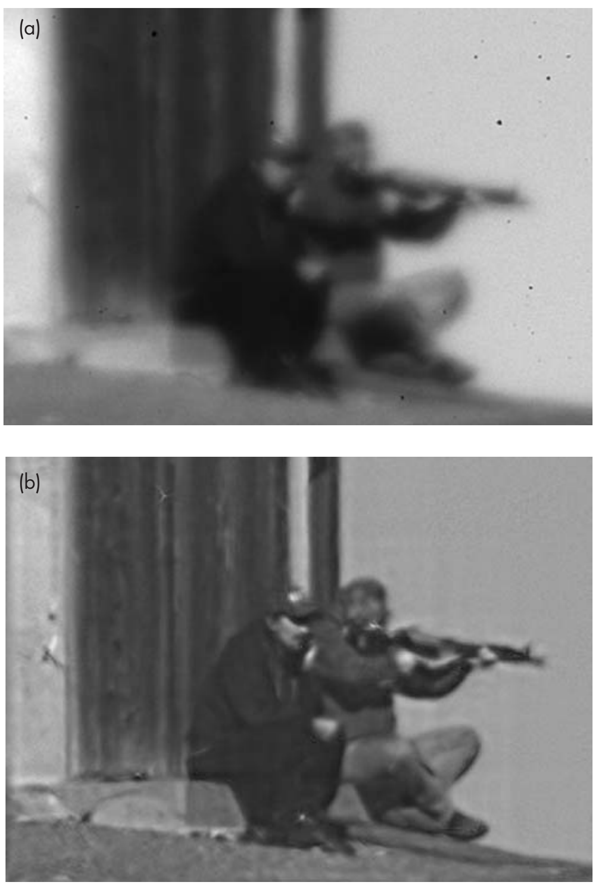

Figure 2. Dennis Silva and Jack Tucker from 2.7 km range at Site 300 through an 8-in. telescope. a) Sample raw unprocessed frame. b) Speckle-processed image from 40 raw frames.

Figure 3. Photograph of the real-time video-surveillance system being tested outdoors.